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Point of operation safeguarding - a metal forming system approach

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POINT OF OPERATION SAFEGUARDING -

A METAL FORMING SYSTEM APPROACH

BY

WILLIAM BAKER EATON

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

AT

NEW JERSEY INSTITUTE OF TECHNOLOGY

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Newark, New Jersey
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ABSTRACT

The mechanical power press in its application in the metal stamping and forming industry has been misinterpreted as a self-contained metal forming system. Examination of the production routines involving the press show that this machine is actually only one elemental component of the metal forming system and not the total production unit.

Authoritative codes and standards pertinent to the mechanical power press have reflected this misinterpretation by not including system considerations in their contents. These omissions have resulted in the providing of safeguards which do not properly reflect the particular characteristics of the metal forming system to which they are applied. This has resulted in the continuing occurrence of point of operation (die closure area) injuries.

Product liability litigation resulting from point of operation injuries has increased substantially in recent years. This has been caused in part by two related factors: the application of non-system oriented codes and standards in judging the propriety of metal forming system performance and the exclusion of statutes of limitations on machinery involved in industrial accidents based on date of manufacture.

These two factors have created unrealistic demands on the performance requirements of the power press and have resulted in less than adequate success in properly determining liability and directing economic recovery for point of operation injuries.

Revisions in present codes, standards and statutes of limitations are necessary if permanent reductions in point of operation injuries are to be realized.

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A METAL FORMING SYSTEM APPROACH
BY
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CHAPTER I

INTRODUCTION

The need for providing adequate protection for the employee in order to insure him a safe and hazard-free work atmosphere is recognized as a common goal of industry. This goal and the need for achieving it are especially critical in the metal stamping and forming industry. The inherently dangerous nature of the production routines performed in this type of manufacturing result in a frequency of worker exposure to hazardous and potentially injurious point of operation (die closure area) situations not normally encountered in other manufacturing fields. Such a rate of exposure demands that operating personnel be provided with proper point of operation protection. In order to accomplish this, an initial requirement is the recognition and understanding of both the individual machine components and the operation of the overall production system that is involved in the manufacturing process being employed. Once this clarification has been achieved, meaningful progress can then be made toward providing proper point of operation safeguards for the system's operator.

Each stamping or forming operation has certain aspects which differentiate that production routine from the next. These special characteristics give each metal forming system a particular complexion with respect to its functional operation and its safeguard needs. The assessing of these needs must be performed with respect to the system and not its individual components if the end results are to prove fruitful.

The mechanical power press is a basic and essential component in a stamping or forming production system. As such, a clear understanding of the press' function or purpose in the production system, as well as a thorough knowledge of its operational capabilities, is a prerequisite to assuring the safety and protection of the operator utilizing it. It is the misinterpretation of the press' function in relation to the overall system involved that is presently a primary obstacle to the providing of proper system point of operation safeguards.

CHAPTER II

THE PRESS - SYSTEM RELATIONSHIP

The design and function of the mechanical power press has been misinterpreted as being that of a complete, self-contained product producing unit. In actuality, the press as a single machine does not constitute a complete system, but rather is only one elemental component of a larger production configuration - the metal forming system.

A metal forming system is generally categorized as either performing a primary or a secondary operation. A primary operation is more commonly known as a blanking process. Here, the system produces the stock or pieces which, in many cases, will be used by another system performing a secondary operation. The blanking operation usually entails the punching or blanking of pieces from roll or strip stock. The secondary operation is more commonly known as a forming process. A metal forming system involved in this type of operation utilizes the blanks produced from a primary operation and forms them into the particular physical shape required.

Although the press is one basic component, the metal forming system also includes: the dies, the actuation

devices, the feed and ejection methods, and the point of operation safeguards (guards and devices). A detailed examination of point of operation safeguards will be provided in Chapter III. The following discussion will serve to clarify the relationship of the remaining four components to the total system.

The Mechanical Power Press

The power press component is a general purpose machine designed to function as the means of supplying the power required to accomplish the metal forming process. Mechanical power presses are normally characterized or identified by their frames.

In general, presses of less than two hundred tons capacity are typified by C-type frames. This frame style is popular because it permits access to the die area from the front as well as both sides. Such access allows for a greater variety of die and feed method combinations. A further development of the C-type press is the OBI or open back inclinable design. This additional feature permits the frame to be tilted backwards permitting gravity ejection of parts or scrap through the open rear area of the frame.

The OBI design is quite functional and is probably the most commonly used in the metal stamping and forming industry. Another adaptation of the C-type is the adjustable bed press. It is similar to the C-type except that its bed is vertically adjustable whereas the C-type is fixed. The horning press represents a further variation of the standard C-type design. Instead of a flat bed, however, the horning press is fitted with a horn or rounded and elongated work bed for use in the production of cylindrical articles requiring riveted, punched or bumped side seams.

Presses exceeding two hundred tons capacity generally incorporate a straight side frame configuration consisting of two or more columns. This type of press has a wider bed than those previously discussed, but does not have the degree of access to the die area that the C-type possesses.

Regardless of variations in design or capacity, mechanical power presses are generally grouped into either of two major divisions by the type of clutch they employ - full-revolution or part-revolution. The full-revolution category includes, among others: sliding pin, rolling key,

sliding key and jaw clutch designs. While these clutches may differ in the particular methods utilized to accomplish engagement and disengagement, presses incorporating these full-revolution clutches possess one common operating characteristic. Once the clutch is engaged, the press ram must complete a full cycle or stroke before the clutch can be disengaged and the ram stopped. As a result of this operating characteristic, full-revolution clutches are provided with single stroke mechanisms included as integral parts of the clutch to insure that only one stroke or cycle is allowed at each engagement. Anti-repeat provisions are also designed into the control systems for these clutch mechanisms. This feature prevents the initiation of another stroke of the press until all tripping mechanisms have been released following the initiation of the previous stroke.

The part-revolution or friction clutch category includes various types of clutches which, regardless of their designs, have certain basic elements in common. These include: sets of opposing friction surfaces, the means of applying torque to and from these surfaces, and the means of maintaining contact between the friction surfaces when required. Part-revolution clutches normally can be engaged and disengaged

whenever desired. Thus, presses incorporating part-revolution clutches in their designs possess the desirable operational ability to permit stopping of the cycle or stroke of the press ram at any position and time following engagement of the clutch.

It is evident, from the basic operational differences between these two major press divisions, that metal forming systems utilizing presses equipped with full-revolution clutches present a greater safety hazard than do those incorporating part-revolution clutches. In addition, since the full-revolution design predates the part-revolution variety, presses incorporating full-revolution clutches are usually much older in years and more amassed in service hours than those employing part-revolution clutches. In many cases, the early vintage full-revolution presses have found their way into metal forming systems as used machines. These machines have experienced varying degrees of alteration to their original designs. As a result, the significance of these alterations in terms of potential safety hazards can only be speculated.

The Dies

The die set or tooling employed in the metal forming system represents the most variable of all the system components. The possible combinations of forms and configurations of dies are literally as numerous as the number of different shapes or forms one is able to imagine. The variety of consumer products available today that utilize stamped or formed metal parts is a graphic illustration of this conceptual spectrum. The designing and building of dies is a highly specialized field and represents an entire industry in itself. While many die building firms commercially design and build dies for industry purchase and use, many stamping and forming businesses design and build their own dies "in house". This has become more prevalent as a result of greater diversification and specialization in product manufacturing.

Dies are divided into two general groupings: cutting or shearing dies and shaping or forming dies. Operations such as blanking, punching or shearing are performed with cutting dies which displace the metal stock between the cutting edges of the dies to produce a shearing fracture. Shaping dies, on the other hand, are employed only to change

the form of a work piece. These dies are used in operations such as bending, drawing or embossing and involve no cutting operation.

Dies differ in material feeding and ejecting arrangements as well as in uniqueness of shape or contour. Side feeding and scrap ejection with bottom part removal is a typical arrangement utilized in blanking operations. Another variation is front-to-rear feeding and scrap ejection with bottom part removal. Forming operations generally use dies which provide a single front or side feed direction combined with either a front, side or rear part ejection provision.

The variety of die forms and configurations, in essence, illustrates the variety of metal forming systems possible. The use of a given die set dictates a potential arrangement of the metal forming system not necessarily required by the previous tooling employed. Practically speaking, the dies play an important role in formalizing the system's composition and arrangement.

The Actuation Devices

Actuation of the press is accomplished by means of

various types of foot or hand operated devices. These devices activate the press control system which in turn engages the clutch mechanism to effect a production cycle of the machine.

Although some early vintage full-revolution presses incorporated two-hand trip levers, most employed a foot pedal or foot-operated lever in conjunction with a mechanical linkage system to cause clutch engagement. As a result of this mechanical linkage system, only one type of actuation device could be used. Full-revolution presses of more recent design utilize pneumatic or electro/pneumatic control systems. Straight pneumatic systems usually employ two-hand trip valve actuation devices, while electro/pneumatic systems are equipped with two-hand push buttons or a single foot switch. These latter actuation devices electrically operate a solenoid valve which actuates the pneumatic portion of the control system and results in clutch engagement.

The vintage of the press, assuming it has not been altered subsequent to manufacture, will usually dictate the type of control system employed and the type of actuation device(s) that may be selected as the means for

operating it. Earlier vintage full-revolution clutch presses which usually utilize straight mechanical linkage controls with single foot-lever operating devices, are obviously lacking versatility of actuation. As a result, these presses have become quite susceptible to revisions in their control system designs in order to employ pneumatic or electro/pneumatic methods of control and to permit the use of the wider range of actuation devices that are available with these types of systems. Most such revisions are performed without the knowledge or advice of the press manufacturer. Thus, while these revisions may appear adequate, the original design of the clutch mechanism of the press may not be compatible with the particular alteration performed. As a result, the altered machine often represents a sacrifice in safety for the sake of convenience.

The Feed and Ejection Methods

The feeding of stock and the ejection of finished pieces can be performed by several methods involving a variety of devices. The oldest and most basic is that of manual feeding and ejection. In many instances, metal forming systems incorporating early vintage presses in their arrangements employ these types of feeding and ejection

methods. In some cases, the die design or the size or shape of the piece being produced may not allow any alternative. In other cases, the decision may be related to economic considerations on the part of the system's designer/user. Regardless of the reason, this type of operator participation in the system's production routine substantially increases exposure to the point of operation and thereby increases the potential for injury. In an effort to reduce this exposure, various handtool devices are available for piece handling. Such devices allow for feeding and removal of work pieces while exposing only the handtool to the die closure area. Handtools, however, are by no means a cure-all. Their use is based more on operator preference than system requirement.

Other manual participation methods include push feeding, follow feeding and slide feeding. The devices used in these methods all offer the same significant safety advantage of permitting manual feeding of stock from outside the point of operation. Push feeding, one of the most widely used methods in secondary operations, involves the use of a slide mechanism. The piece to be worked is placed in the slide which is then pushed between the dies. Follow

feed devices, which include magazine-loaded types, provide another popular secondary operation feeding method. Pieces are released from the magazine and fed to the dies by manual or mechanical operation of a release mechanism integral to the device. Slide feeding, used in both primary and secondary operations, utilizes both mechanical slide and gravity slide devices. As their names imply, one method assists the piece along the slide by mechanical means while the other takes advantage of gravitational benefits.

In addition to these manual feeding methods, a variety of automatic feed devices are usually employed in continuous blanking and forming operations where strip stock is used. In such arrangements, some type of powered or unpowered stock reel is included to feed stock to the feed device. Roll feeds, air feeds and mechanical grip feeds are three of the most frequently employed methods. Each of these devices is coordinated with the press to advance the feed stock a fixed distance following each forming stroke of the press ram. Such systems may also incorporate a straightening device, located between the stock reel and feed device, that flattens the strip stock being fed from the reel to the feeding device at the press.

Several methods of part ejection are commonly used in the performance of the metal forming process. Achieving proper parts ejection without requiring operator participation is not only beneficial from an efficiency standpoint, but plays a substantial role in protecting the operator from exposure to the point of operation during the unloading segment of the production cycle of the press.

Knockout ejection, the most typical method used to knock or kick the finished piece out of the upper die half, employs knockout pins which are extended out of the die during the upstroke of the press. The pins, in extending above the surface of the die half, separate the piece from the die surface. Smaller OBI presses frequently use this method, although it is also used on larger presses when blanking dies are being employed.

An air blast ejection arrangement is normally used on presses involved in small parts production. In small parts blanking and forming type processes, the pieces, being light in weight, are blown out of the die into a chute or box collecting arrangement. The air blast method is customarily used in conjunction with knockout ejection. Whether

used alone or in concert with the knockout method, this technique utilizes a nozzle configuration which directs a short duration blast of air at the finished part when the press ram is making its upstroke. One variation of this method employs holes drilled into the die as nozzles.

Gravity and mechanical ejection represent two other standard part removal techniques. Gravity ejection is normally used only in blanking operations where the die configuration permits the finished blanks to drop through the lower die half into a collecting arrangement.

Mechanical ejection, on the other hand, is more versatile and frequently combines features included in the other ejection methods. Standard mechanical ejection devices include the latch, toggle and shuttle types. The latch type is mounted on the upper die and lifts the finished part out of the die on the upstroke of the press ram. The toggle device is attached to both die halves and is used in conjunction with a knockout arrangement. As the ram is making its upstroke, this device swings into the point of operation and catches the piece as it is ejected by the knockout. The subsequent downstroke of the ram retracts

the toggle device from the die closure area, and the piece it is conveying falls by gravity to a collecting bin. This device is a positive means of ejection, as it is operated directly by the press ram. Another widely used mechanical ejection device is the shuttle type which incorporates a horizontal slide or table. The slide is propelled by a chain drive or air cylinder arrangement and travels into the point of operation during the upstroke of the press. The finished part falls from the knockout onto the slide (table) which then retracts from the die area and deposits the part into a collecting arrangement. The shuttle device is operated electrically and is actuated through a system of limit switches mounted on the press frame and a cam arrangement mounted on the press ram.

Operating experience has shown that metal forming systems which include full-revolution clutch equipped presses and manual piece feeding methods represent system arrangements most involved in point of operation injuries. An analysis of 306 reports of point of operation accidents occurring between July 1, 1975 and December 31, 1975 was performed by the Office of Standards Development, Occu-

pational Safety and Health Administration.¹ The results of that study verify the above statement. Their analysis revealed that of the 306 accidents, 257 occurred during normal operation. Of this number, 169 accidents involved forming systems whose press components incorporated full-revolution clutches. With respect to the method of feeding employed, 115 of the 257 accidents resulted from manual "hands in dies" feeding operations while an additional 79 accidents involved some type of manual "hands out of dies" feeding method. In contrast to these figures, metal forming systems incorporating presses equipped with part-revolution clutches were involved in only 77 normal operation accidents. Likewise, metal forming systems utilizing automatic or semi-automatic feeding methods were involved in only 33 of the 257 total injurious occurrences.

In light of the many variations and combinations of components that may be combined to create a particular metal forming system, it is evident that the individual

¹U.S. Department of Labor, Occupational Safety and Health Administration, Office of Standards Development, Semi-Annual Report entitled Analysis of Reports of Point of Operation Injuries on Mechanical Power Presses, (Washington, D.C.: Government Printing Office, 1976), pp. 1-11.

function of the press, as with each of the other components, has no practical relevance to the function of the total system or the degree of safety that arrangement possesses until the press is incorporated as a part of the complete metal forming unit. Only after this has occurred can the particular function of the press in that system be properly defined and evaluated. This is especially significant with respect to providing adequate system point of operation safeguards.

As previously indicated, the press is a general purpose machine. It is designed to be used with a variety of dies of different forms and configurations, each of which may be particular to one specific forming operation. Quite often, a given die will be used for a short period of time or only for a given run and then will be replaced by another of dissimilar configuration. In addition to accepting a variety of dies, the press can be adapted to various methods of material feeding, part ejection and actuation depending on the particular system's requirements. In the case of early vintage presses whose designs usually provided only a single means of actuation, the adaptation of the press control to incorporate additional actuation capabilities

may in turn have created new potential operating hazards.

Once the die set, means of actuation and methods of material feeding and part ejection have been determined, the press can then be properly equipped with a point of operation safeguard configuration which will be compatible with the total system and provide adequate protection for the operator.

Failure to recognize the component function of the press, mistakenly viewing it as the total system, has fostered the belief that the press manufacturer should assume full responsibility for providing the point of operation safeguards required by the production system. Such a view is inconsistent with the chronological pattern of design and assembly associated with the system itself.

At the time of manufacture of the power press component, the particular configuration of the complete metal forming system into which the press will be included is not known. As a result, the press manufacturer has no factual means of determining what other components will be utilized with his press. Without this information, the final arrangement of these pieces of equipment in the system,

as well as with respect to the press, cannot be clarified. Therefore, from a practical engineering standpoint, the press manufacturer cannot be responsible for providing point of operation safeguards for a production system which, at the time of shipment of the press, has not yet been defined.

Safeguard designs based upon a "general purpose" or "universal" philosophy cannot be expected to adequately reflect the dictates of every system's specific characteristics. In many cases, the incompatibility of such designs may not only present operational difficulties, but, more importantly, may in themselves create additional hazards when incorporated into the system's production routine or arrangement. It is for this reason that the advocacy of "universal" safeguards, to be supplied as integral components of power presses by their manufacturer's, represents an ill-conceived and unsafe approach toward the providing of adequate system point of operation safeguards for protection of the operator.

Specificity is an essential consideration in the provision of proper system point of operation safeguards. Each metal forming system has certain particulars associated with

it which make that system unique unto itself. These specific characteristics may occur as a result of the type of components being employed, the manner in which the system is arranged, or as a result of the particular forming process being undertaken (e.g. special deep draw forming). If they are to be effective, point of operation safeguards, utilized by a system, must reflect that system's unique qualities in their own design and construction. First, therefore, to accomplish this satisfactorily, the metal forming system where these safeguards will be employed, must be fully defined.

CHAPTER III
SYSTEM CONSIDERATIONS IN PROVIDING
POINT OF OPERATION SAFEGUARDS

The ultimate design of the metal forming system, in component content and physical arrangement, is dependent upon many "in house" production considerations to which system component manufacturers are not privy. These production factors serve as the basis for the design and specification of the metal forming system and its point of operation safeguards. Failure to properly consider such system factors with respect to point of operation protection can only increase the potential for operator injury.

The particular piece or part to be produced is a fundamental consideration in the assembly of any production system. The design of the piece usually dictates the general process operation that will be employed. This, in turn, normally provides a guideline as to the components which will be required in the system's final arrangement. The general process to be performed also provides an indication as to the alternatives available with respect to the system's operating mode.

Primary or blanking operations usually warrant more component devices in the system than do secondary operations. However, primary routines generally lend themselves more readily to continuous operation than do secondary types, by virtue of the characteristics of the process being performed. The various dies used in such blanking operations are designed to accomodate strip stock feeding, as opposed to individual piece insertion, and to automatic, as opposed to manual, part ejection. Thus, feeding of these systems normally involves the inclusion of some type of powered or unpowered stock reel as the means of supplying the strip stock material. Compatible feed devices, such as roll, air or mechanical grip, must also be included to convey the stock to the dies. In addition, an appropriate method of parts ejection is also necessary and, frequently, a straightening device, used to flatten the strip stock before contact with the particular feed device, is also customarily provided.

Metal forming systems performing secondary or forming operations normally involve fewer components than the primary types. In addition, the general forming nature of this type of operation results in greater utilization of the

manual function available from the operator. As a consequence, these systems are of a greater concern from the standpoint of point of operation exposure than the normal continuous blanking type processes.

Early vintage mechanical power presses are more easily assimilated into forming processes as these routines do not require the degree of speed or continuous operation usually desired in primary production processes. Thus, the utilization of full-revolution clutch equipped presses is common, consequently adding additional concern with respect to point of operation injury.

As in blanking, the piece being formed in a secondary operation dictates the die configuration which, in turn, determines the method of part feeding and ejection to be used. The least desirable method, of course, involves "hands in dies" insertion and removal of parts. Unfortunately, certain part configurations preclude the use of any other method. For the most part, however, forming operations permit the inclusion of a variety of "hands out of dies" feeding and ejection devices, as well as various means of press actuation.

The overall plant arrangement can be a significant factor in the final configuration and safety level of the metal forming system. The area or position in the plant layout designated for the metal forming system may well affect the choice of system components where alternatives are possible. Restrictions due to availability of space or physical arrangement may necessitate employing an alternative system arrangement not as productive or as safe as the primary choice. Consider the following example: A blanking process is to be performed and the metal forming system is to be on continuous operation. The system is to employ a stock reel in conjunction with a roll feed device to convey material to the die set. Upon surveying the proposed plant location for the system, it is observed that physical limitations in the area do not provide sufficient operating space to allow the use of a stock reel and roll feed setup. A manual feeding arrangement is the only method possible in the area provided. Since the production process is required, an alternative system configuration involving operator participation with single stroke press operation and manual part feeding has to be utilized. This alternative system obviously presents greater potential danger to the operator from the perspective of point of operation injury.

Thus, it is important for the system designer/user to consider both plant locale and space availability factors in order to provide the best system arrangement from a safety as well as a productivity standpoint. System component manufacturers do not have the information required to provide such a design function.

The compatibility of the metal forming system's production process with adjacent processes and work routines is also a significant factor with respect to the system's arrangement and degree of operating safety. For example, a metal forming system employing "hands in dies" feeding and ejection methods is significantly more hazardous to its operator when located adjacent to noisy or disturbing work processes or distracting work routines. A "hands in dies" system arrangement requires the operator's undivided attention. Varying levels of operator fatigue are nearly always produced by the repetition associated with the process performed by such a system. Surrounding distractions can easily interrupt the operator's physical coordination and mental attention to the system's production routine. As a result, the potential for point of operation injury is increased. Wherever possible, alternative locations for

this type of metal forming system should be considered. If no alternative is available, even greater attention must be given to the providing of adequate system point of operation safeguards. Such "in house" conditions cannot be foreseen from any practical standpoint by the various system component manufacturers. Therefore, the system designer/user must bear the responsibility to provide the operator with adequate point of operation protection.

Taking the above factors into account, a variety of possible system configurations could still be designed to accomplish the production process required. Some will be more productive, while others will present more of a safety hazard to the operator. The ultimate decision as to the particular metal forming system's arrangement, including the point of operation safeguards, remains that of the system designer/user. A significant factor in that regard is his production or operating philosophy. If the system designer/user is safety oriented, he will be cognizant of the various system alternatives available to accomplish a particular production process and of the degrees of operator safety associated with each. Wherever possible, he will utilize continuous system arrangements so that operator

participation is kept to a minimum. Where situations preclude the use of continuous operation, every effort will be made to include system components which will permit the operator to function in a "hands out of dies" system arrangement. When "hands in dies" feeding and ejection are required, proper handtools will be readily available for use. Most importantly, adequate and suitable point of operation safeguards for this, as well as the aforementioned arrangements, will be integral to these systems' designs.

The foregoing tangible and intangible production factors or considerations serve to finalize the component categories which must be represented in the design of the metal forming system. The specific die set required for the production of the part desired, although a system component, serves to further limit both the possible arrangement configurations of the system and the alternative choices of devices available within each of the other component categories needed to perform the production process under consideration. The die configuration will indicate its degree of adaptability or compatibility to various feeding and parts ejection arrangements and will essentially define the range of alternative devices in these component categories that may be

employed in the particular system. The alternatives available with respect to component arrangement in the system are also reflective of the particular die set being utilized. Directional considerations pertaining to the feeding of stock and the ejection of parts must be compatible with the provisions included in the die configuration for those functions. As a result, the devices included to perform these functions must be positioned so that they will be properly oriented with respect to the particular sections of the die set pertinent to these operations.

The particular die configuration utilized in the system also affects the actuation devices that might be used and the mode of system operation. For example, the die set used for a primary operation, such as stamping parts from strip stock, usually permits a continuous mode of system operation which only requires the operator to provide a sustained signal from a given actuation device. In contrast, another die set used to perform a primary trimming operation may require the operator to manually insert the piece into the dies, maintain it in a stable position, as well as actuate the press during the trimming process. As a result, the press and system must be operated on a single stroke basis.

In addition, since the operator's hands are occupied during the trimming operation, a foot-type actuation device is required. Although these two metal forming systems are performing the same category of operation, the particular die set being employed in each of these primary processes has resulted in significantly different system arrangements and operating modes.

The component hardware constituting the particular metal forming system and its physical arrangement are the end result of the system designer/user's decisions with respect to the above considerations, with one exception. The point of operation safeguards for this finalized system have not yet been provided. Heretofore, appropriate consideration in this important area of system safety was not possible since the system did not exist. However, once the physical components and their arrangement in the system have been determined, the operational requirements of each component and the relationship of those functional aspects to the system's operation can be clarified.

It is essential that such component operating characteristics be considered when providing point of operation protection for the system. Guards must reflect the partic-

ular characteristics of the system if they are to be effective. Such protective configurations must permit proper operation of the system and simultaneously prevent unsafe access to and injury from the point of operation. The point of operation guards provided must make the necessary physical provisions in their configurations for the feeding and ejection methods being used, access for remedial procedures such as removal of jammed pieces and reasonable visibility to facilitate monitoring of the production process. At the same time, however, these guards must provide the protection necessary to prevent access to the point of operation. The safety devices employed must properly protect the operator while also providing him the mobility required to adequately perform his activities in the system's production routine. Satisfactory accomplishment of their safety function can only be realized if these guards and devices reflect the particular operating characteristics of the system utilizing them.

Various categories of point of operation guards and devices are available which, through operating experience, have been found to be effective when properly used. Before reviewing these categories, it is first important to formally

clarify the distinctions between a point of operation guard and a point of operation device. Section 2, paragraph 2.21 of the American National Standards Institute's ANSI B11.1 - 1971 Standard, entitled "Guard," defines a guard as follows:

"The word guard means a barrier that prevents entry of the operator's hands or fingers into the point of operation."²

Paragraph 2.8 of the same Section, entitled "Device," defines a device as follows:

"The word device means a press control or attachment that:

- 1) restrains the operator from inadvertently reaching into the point of operation, or
- 2) prevents normal press operation if the operator's hands are inadvertently within the point of operation, or
- 3) automatically withdraws the operator's hands, if the operator's hands are inadvertently within the point of operation as the dies close."³

With reference to point of operation guards, para-

²American National Standards Institute, American National Standard Safety Requirements for the Construction, Care and Use of Mechanical Power Presses, B11.1 - 1971 (New York: American National Standards Institute, Inc., 1971), p. 18.

³Ibid., p. 14.

graph 5.2 of Section 5, entitled "Point of Operation Guards," requires that among other provisions:

"Every point of operation guard shall meet the following design, construction, application and adjustment requirements:

- 1) it shall prevent entry of hands or fingers into the point of operation [die closure area] by reaching through, over, under or around the guard, and . . .
- 3) it shall, in itself, create no pinch point between the guard and moving machine parts, and
- 4) it shall utilize fasteners not readily removable by operator, so as to minimize the possibility of misuse or removal of essential parts, and
- 5) it shall facilitate its inspection, and
- 6) it shall offer maximum visibility of the point of operation consistent with the other requirements."⁴

Section 5, paragraph 5.3, entitled "Point of Operation Devices," states:

"A point of operation device shall protect the operator by:

- 1) preventing or stopping normal stroking of the press, or both, if the operator's hands are inadvertently placed in the point of operation, or
- 2) preventing the operator from inadvertently reaching into the point of operation or withdrawing his hands, if they are inadvertently located in the point of operation as the dies close, or

⁴Ibid., p. 34.

- 3) preventing the operator from inadvertently reaching into the point of operation at all times, or
- 4) requiring application of both of the operator's hands to machine operating controls during the die closing portion of the press stroke, or
- 5) locating single cycle operating controls so that the slide [ram] completes its downward travel before the operator's hands can inadvertently reach into the point of operation."⁵

Section 1910.217, entitled "Mechanical Power Presses," of the Occupational Safety and Health Administration's Occupational Safety and Health Standards embraces similar requirements.

The category of point of operation guards includes four basic types: fixed barrier, die closure, interlocked barrier, and adjustable barrier guards.

The Fixed Barrier Guard

The fixed barrier guard protects the point of operation by completely enclosing the hazardous area with an enclosure type shield or barrier secured to the frame or bolster plate of the press component. Usually constructed of metal or a

⁵Ibid., p. 37.

combination of metal and plexiglas, the fixed barrier guard is designed for strength and prolonged use, is simple in design, permanent in installation, highly effective, and requires minimal maintenance. It is particularly preferable since it can be designed and constructed to meet specific system characteristics while still providing a positive guarding function. The fixed barrier guard is an especially effective means of protecting the point of operation of metal forming systems employing continuous operation or "hands out of dies" feeding and ejection methods. However, some disadvantages of this guard include the reduction of visibility and, in many cases, its physical removal for the performance of remedial adjustments, maintenance or repairs in the vicinity of the die closure area. In its application, the fixed barrier guard can only provide adequate protection if its configuration is tailored to the system's needs and this can only be accomplished by first defining the system. The specific needs of a given system prevent the providing of a proper fixed barrier guard on the press component prior to its inclusion in the system arrangement.

The Die Closure Guard

The die closure guard is similar to the fixed barrier guard except that it is attached to the die shoe or die assembly base rather than the press. Like the fixed barrier guard, this guard is also stationary and, in many cases, is attached to and made a permanent part of a particular die set. This is advantageous from the standpoint that the die closure area (point of operation) will always be provided with point of operation protection, except during die setting procedures. While the die closure guard is effective, it does limit a given die set to a particular feeding and ejection routine which is disadvantageous in situations where dies permit alternate arrangements of these functions. Like the fixed barrier, the die closure guard must be fitted to the system in order to be adequately compatible. It is important that ram travel of the press be considered when providing this type of guarding configuration. In particular, the arrangement must insure that the ram, at its uppermost position, will be at least one inch lower than the top of the die closure guard. If the ram is higher than the top of the guard, a shearing hazard will be created when the ram descends during operation. Prior to its design and construction, this type of guard requires specification of

the die set, press, and feeding and ejection component devices. Without this system formalization, an adequate guard configuration cannot be provided.

The Interlocked Barrier Guard

The interlocked barrier guard is attached to the press frame or bolster and encloses the point of operation in a manner similar to the fixed type. This guard, however, is equipped with hinged or movable sections, each of which is interlocked by mechanical or electrical means with the press clutch control. Thus, removal or positioning of the movable portion(s) of this guard out of the operating or safe position, will prevent operation of the press. It is important to understand that the hinged and movable sections of this type of guarding configuration are intended for use as access ways for setup, die adjustments and the performance of other similar remedial procedures. They are not provided or intended for use as a means of feeding or parts ejection during the regular operation of the press and system. If used in its proper capacity, the interlocked barrier guard is an appropriate alternative to the two previous guards, since it provides a greater degree of operator flexibility. However, there are disadvantages. This guard's success

is predicated on careful maintenance and adjustment of the interlock switches or devices. Also, like most interlocking arrangements, the susceptibility to operator interference with or bypassing of the interlock devices, reduces the safety potential of this type of guard. In addition, the interlocked barrier guard does not provide positive protection against a mechanical repeat (unwanted stroke) of the press as do the fixed barrier or die closure guards. If properly adjusted and maintained, however, this guard can provide satisfactory protection for the operator. In metal forming systems using presses with full-revolution clutches, this type of guard is only permitted to be used when the press is operated in the single stroke mode. Proper application of this interlocked barrier guard configuration requires adequate consideration of the system's components as well as its operating modes.

The Adjustable Barrier Guard

The adjustable barrier guard is attached to the press bed, bolster plate or the die shoe (base). This configuration differs from the fixed barrier type in that the protection barrier or shield of this guard is adjustable whereas the fixed barrier is not. The adjustable barrier

is usually constructed of individual vertical sections of bar stock, each of which can be positioned and secured where required. The operator should be required to use a mechanical tool as a proper means of securing each bar. The adjustable barrier guard has the advantage of greater adaptability than the aforementioned guards and is generally considered to be as effective as the fixed type if adjusted and secured properly. However, this guard is quite susceptible to operator tampering and misadjustment. Although the adjustable barrier guard is more versatile than the other types, its effective application requires compatibility with the complexion of the particular metal forming system involved, since the guard can be attached to either the press or die component. As a result, until the system is defined and these components are specified, the particular configuration of the adjustable barrier guard and its mounting location cannot be properly determined.

The most effective types of point of operation devices, commonly used to reduce exposure to the die closure area, are: the gate or movable barrier, pull-out or pull-back, hold-out or restraint, sweep or push-away, presence-sensing, two-hand control, and the two-hand trip.

The Gate or Movable Barrier Device

The gate or movable barrier device is designed to enclose the point of operation before the press can be operated, and stop the press if the gate is opened during operation. This device usually consists of a fixed barrier enclosure with a movable section permitting access to the point of operation. The movable barrier or gate section of the device is interlocked with the press control to prevent operation unless it is in the proper protective position. However, the device cannot protect against a mechanical repeat of the press. Although similar in description to the interlocked barrier guard, the gate's usage is significantly different. The interlocked section of the barrier guard is provided only as a means for gaining access to the point of operation for the purpose of performing remedial procedures. It is not provided as an access way to be employed as part of the normal production routine. The movable barrier section of the gate device, however, is provided as the normal means of access to the point of operation to accomplish part feeding and, in many cases, ejection of material. Its operation, therefore, is an integral part of the production cycle. The gate or movable barrier device is an effective means of operator

protection when properly adjusted and maintained. This device, as with all configurations employing interlocking designs, however, is susceptible to operator interference or bypassing as well as improper or unsafe operation due to inadequate adjustment. It is further restricted in its use in metal forming systems using full-revolution clutch equipped presses. While the interlock design is capable of preventing engagement of the full-revolution clutch when the gate is not properly positioned, once the press is actuated, the stroke cycle cannot be stopped even if the gate is moved out of the "operate" or protective position. Thus, when the movable barrier device is used in this type of system, the press must be operated in the single stroke mode. In addition, the device must be applied so that once the press is tripped, the operator cannot open the gate and gain access to the point of operation prior to the press ram completing its full downward stroke. The full protective potential of the movable barrier device is better realized when used in conjunction with presses equipped with part-revolution clutch mechanisms. Proper usage of this device also requires that the production routine of the system be considered in its design and that the device be compatible

with feeding and ejection methods. If the gate or movable barrier device annoys or interferes with the operator's routine to any significant extent, it will only increase the possibility of the operator bypassing the interlock protection provided. Proper consideration of the system's operation can reduce this potentially hazardous possibility.

The Pull-out or Pull-back Device

The pull-out or pull-back is a widely used protective device which is adaptable to many metal forming system arrangements. The design of this device includes hand or wrist attachments which are connected by a system of pulleys and cables to the press ram or upper die. The cables are normally adjusted so that when the ram descends, the operator's hands are pulled back and clear of the point of operation before the dies close. When the ram is in its top position, access is permitted. The pull-back device can also be adjusted so that the operator is never permitted access to the die closure area. This method of adjustment requires the use of a handtool if manual feeding and/or ejection is being performed and, although more restrictive and inconvenient, does increase the safety potential of the device. Although quite adaptable to varying system arrange-

ments and operating conditions, the pull-back's potential for providing adequate protection for the operator is based upon two tenuous criteria. First, the operator must use the device. Pull-backs are not interlocked with the press control in any way and their usage, therefore, is discretionary. This is always an unsatisfactory characteristic for a protective device to possess since aspects such as convenience of operator movement, disregard for safe work practices, and improper supervision are able to directly affect the protective potential of this type of device. Secondly, even when used, pull-backs require unusually good adjustment and maintenance in order to adequately function in a protective capacity. Slight alterations in a specific system operation, frequently require readjustments of this device not required on other types of safeguards. However, pull-backs can be effective when properly adjusted and maintained and a conscientious effort is undertaken to insure that they are properly used. Their application must be predicated on knowing the metal forming system's composition and mode of production. The system requirements on operator mobility are of primary concern when pull-backs are considered. If pull-backs are employed, the arrangement of system components may create an excessive obstruction

of operator work space which might not result from an alternate protective configuration. In order to avoid such difficulties and to insure an effective level of operator protection, the system must be fully defined and understood in order to properly determine the applicability of this type of device in the particular production routine being performed.

The Hold-out or Restraint Device

The hold-out or restraint device, like the pull-back, includes attachments for the operator's hands or wrists. Unlike pull-backs, however, the hold-out's cables are secured and adjusted in such a manner that when the attachments are worn, the operator is restrained from reaching into the point of operation at all times. As with pull-backs, the use of this device is discretionary and, thus, presents the same undesirable characteristics in that regard. Restraints, however, provide a more positive means of protection than pull-backs in that their correct adjustment is more easily achieved and maintained. As restraints are designed to be especially restrictive, the operator's role in the production process must permit him to work within the confines the device allows. If not provided with

adequate mobility and comfort, the operator will most likely not wear them. This occurrence is especially prevalent in systems where manual methods of feeding and parts ejection are used. If the restraints obstruct the operator's ease in placement and removal of parts, he will, out of necessity, be forced to work without them and, therefore, lose their protective function. In order to determine if the application of this device will result in an effective means of point of operation protection, the system designer/user must insure that the restraint is compatible with the system's components and the production cycle.

The Sweep or Push-away Device

The sweep or push-away device consists of a movable barrier mounted on a sweep arm, which is normally attached to or actuated by the press ram. In operation, the leading edge of the sweep barrier moves across the front of the point of operation as the ram descends, pushing the operator's hands clear of the die area. The trailing edge of the barrier simultaneously restricts access to the die set prior to the completion of the press ram's full downstroke. An alternate manner of operation can be used where the sweeping action is initiated prior to actuation of the

press clutch and descending of the ram. The use of a sweep device also requires partial enclosures on each side of the point of operation, to prevent access to the point of operation by reaching around or behind the sweep device. Application of this device to the metal forming system requires careful consideration of the system's press and die components. With respect to the press, the system designer/user must insure that the action of the sweep does not, in itself, create additional shear or impact hazards, which can occur due to the location of tie rods or other portions of the machine. The system designer/user must also be aware of the width of the die set being used in the system. If the die set is too wide, the sweep device will not have the side-to-side operating range needed to prevent access to the die closure area at all points during its travel. Another system consideration concerns the compatibility of the sweep's direction of travel (left-to-right or right-to-left when facing the press) with the operator's dexterity. If the operator is right-handed, any normal feeding or part ejection will most likely be accomplished using his right hand. In this situation, right-to-left travel of the sweep device is required in order to insure contact with the operator's hand as soon as the ram begins motion or the

clutch is actuated. Likewise, if the operator is left-handed, left-to-right sweep travel is necessary. Although advantageous in permitting complete access to the point of operation for the purpose of feeding and removal of parts and for the performance of remedial procedures, the sweep device has several disadvantages. Unless it is adjusted to the proper height and sweep speed and unless the operator's hands are in the normal position during press operation, the device will not properly prevent access to the point of operation. Because of these disadvantages, OSHA has prohibited the use of this device as a primary means of safeguarding since December 31, 1976. However, when employed in conjunction with another point of operation safeguard, it can be used in a secondary capacity. In considering use of this type of device, its operational disadvantages must be evaluated in light of the system's operation as well as its compatibility with the primary guard or device being used before its applicability as an effective secondary means of point of operation protection can be determined.

The Presence-sensing Device

The presence-sensing device most commonly used as a means of point of operation protection is the photoelectric

type, which consists of a light beam source and an electric eye receiver. The electric eye is interlocked with the press control circuit to prevent or stop press operation if the light beam is interrupted. While effective if properly adjusted and maintained, this device can only be used in metal forming systems with part-revolution clutch equipped presses. Although this device will prevent initiating operation of a full-revolution press, it cannot stop operation once the clutch has been engaged for a cycle. When used with part-revolution presses, care must be taken to insure that the operating cycle speed of the press is not too great that the stroke cannot be stopped quickly on command of the photoelectric device. The device does not protect against a mechanical repeat of the press. Aside from requiring regular maintenance and adjustment, the presence-sensing device is initially quite expensive. In addition, the method of feeding and ejection of parts must be considered, as more than one device might be required in order to provide the protection necessary as a result of these factors.

The Two-hand Control Device

The two-hand control device can be used as a point of

operation device as well as a means of press actuation. This type of device normally consists of two palm buttons electrically integrated into the press control circuit. In order to use such a device in this protective capacity, the press involved can only be equipped with a part-revolution clutch. In addition, the device must require the concurrent use of both hands to start and maintain the press stroke at least until the ram has completed its full downward travel. The two-hand control is very effective since both of the operator's hands are needed to operate the device and, therefore, cannot be in the point of operation when the press ram is descending. Although advantageous from the standpoints of requiring only minor maintenance and being inexpensive to install, the two-hand control device has two disadvantages. First, the system can be circumvented unless equipped with an anti-repeat provision which requires complete release of both palm buttons between press strokes. Secondly, this device does not protect against a mechanical repeat. Use of the two-hand control device in the metal forming system, in addition to insuring that the press component is equipped with a part-revolution clutch, requires that the operator have both hands free during the production stroke of the press. If the particu-

lar system's operation requires the operator to use either hand to manually stabilize the part being worked, as in a trimming operation, the two-hand control device would not be appropriate. It is important that the press, as well as the production routine, be properly evaluated when considering use of this device.

The Two-hand Trip Device

The two-hand trip device is mechanically or pneumatically integrated into the press control system, and performs its function in a manner similar to the two-hand control, except that it is used on presses equipped with full-revolution clutches. While requiring the concurrent actuation of both tripping means to initiate the press stroke, this device differs from the two-hand control since the device need not be held actuated in order to continue the stroke once the clutch has been engaged. Since the operator is not required to maintain his hands on the tripping means during the total downward stroke of the ram, proper location of the two-hand trip device is important. The device must be positioned so the distance between it and the die closure area does not provide the operator sufficient time to actuate the device and reach the point of operation before the

ram has completed the full downward portion of its stroke. The evaluation of the metal forming system's production routine and its press component, in particular, are required in order to determine the suitability of the two-hand trip for use as a means of point of operation protection. In this regard, the press component must be of high speed and short stroke, with a full-revolution clutch, and the system arrangement and production routine must permit the operator's hands to be free to actuate the press cycle. In addition, the system must provide a location for installation of the two-hand trip device which will prevent the operator from reaching the point of operation during the die closure portion of the press stroke.

In order to gain adequate advantage of the protective safety function offered by any of the above guards or devices, that safeguard must be compatible with the particular production routine involved. This routine is defined by the content and arrangement of the metal forming system and is the end result of the "in house" production decisions of the system designer/user. Until such decisions are formalized and translated into the system's physical production equipment, a meaningful and effective approach to

the providing of necessary point of operation protection is not possible.

Individual component guarding, prior to any definition of the metal forming system's design or arrangement, has been advocated as a viable alternative to a system approach in the provision of point of operation protection. The component approach, however, has a number of undesirable and, in many cases, hazardous ramifications. Evaluation of each component on its own merits, without regard for its relationship with other equipment, may permit the inclusion of adequate protection for the particular component involved. Unfortunately, the individual component is not operated as a single, isolated unit, but is used in conjunction with other related pieces of equipment. Thus, the component's functional application, as well as the resulting relationships between it and associated equipment, cannot possibly be reflected in the individual point of operation protection provided. Protection which may be adequate for one component, may be totally inadequate for the system in which it is included. Safeguard incompatibilities may substantially reduce the speed and efficiency of the system's operation or prevent its production routine

altogether. More importantly, the inclusion of such safeguard arrangements may adversely affect system safety by either creating additional hazards or by reducing the effectiveness of other components' safeguards.

CHAPTER IV

PRESENT CODES AND STANDARDSAND THE METAL FORMING SYSTEM

Present authoritative codes and standards fail to recognize or reflect the general purpose nature and component function of the mechanical power press as one element of the metal forming system. Their misinterpretation of the press as a self-contained, complete production unit, has resulted in the omission of any consideration of aspects relating to the nature or function of the metal forming system and its relationship to the safety of the operator. As a result, the viability and validity of these authoritative sources as instructional and regulatory documents is substantially reduced.

By failing to recognize that the metal forming system consists of more than the power press component, the codes and standards include no instructional recommendations, guidelines or requirements with respect to the responsibilities of individual component manufacturers toward the system. There are no recommended or required specifications relating to design configurations or types and grades of materials to be used in the construction of system components. Of

particular significance in this regard is the absence of any requirements with respect to maximum expected component life. At present, there appears to be no limitation as to the required life of the press or any of the other system's components.

Similarly, the codes and standards provide no system-oriented requirements or recommendations with reference to the responsibilities of the system designer/user (usually the employer). No recognition is given to specific parameters or guidelines with respect to the design, content, arrangement or operation of the metal forming system. The individual component designers do not have the system information available at the time of the design and manufacture of their products to accomplish these tasks. Further, no stipulations with respect to the press, for example, are set forth to regulate its use or non-use in a particular production configuration. As a result, the design and arrangement of the metal forming system and its degree of operating safety are based on the designer/user's own criteria. This is especially significant when the system designer/user is formulating a production routine involving the use of early vintage system components in conjunction

with a "hands in dies" feeding and ejection method. Such systems do not have the benefits of technological advances in the areas of machine design, system control, and operating safety which are reflected in the more advanced components of newer arrangements. Thus, it is all the more essential to provide the system designer/user with the guidance necessary to insure that the system created will provide a safe and acceptable means of accomplishing the production process being performed.

Proper point of operation safeguards are essential to the providing of such a safe and acceptable metal forming system. Satisfactory fulfillment of this protective function initially requires a thorough and effective analysis of the system to determine the type of guards and devices necessary to afford the operator the protection required. Once this determination has been made, the system designer/user is then able to provide, properly install and adjust the particular guard or device best suited for the system's characteristics. The codes and standards include no instructional information, however, to assist the system designer/user in these endeavors. No specifications recommend or set forth a formal method of system analysis. In addition,

no design or material requirements are provided to insure uniform standards of strength, quality, durability and performance for point of operation guards and devices. The codes and standards neither address themselves to any specifications regarding installation methods and materials nor prescribe procedures for insuring proper guard or device adjustment and functional testing prior to "on line" use by the operator. These omissions serve to open the "flood gates" of interpretation in an area where "specifics" are essential.

A short review of the contents of applicable authoritative sources will amply illustrate the aforementioned observations. The recognized and accepted authoritative power press standards are the American National Standards Institute's Standard ANSI B11.1 - 1971, entitled "Safety Requirements for the Construction, Care and Use of Mechanical Power Presses," and the Occupational Safety and Health Administration's Occupational Safety and Health Standards, Sections 1910.211(d) and 1910.217, respectively entitled, "Definitions" and "Mechanical Power Presses." As the OSHA Standards embrace the same provisions and intent as ANSI B11.1, an analysis of the ANSI Standard will pro-

vide a valid indication of the misinterpreted nature of the power press that pervades the provisions of these documents.

At the outset, Section 1, paragraph 1.1, of ANSI B11.1 - 1971, entitled "Scope," serves to portray the metal forming system as a single machine by stipulating that:

"The requirements of this standard apply only to those mechanically powered machines that shear, punch, form or assemble metal or other materials by means of tools or dies attached to slides, commonly referred to as mechanical power presses."⁶

Paragraph 1.2, entitled "Purpose," further emphasizes the lack of recognition of the existence of the metal forming system by clarifying the Standard's intent as follows:

"The purpose of this standard is to establish safety requirements with respect to the construction, care, and use of mechanical power presses."⁷

As is clearly indicated in these two paragraphs, this Standard does not recognize or address itself to the relationship between the press and the metal forming system of which it

⁶Ibid., p. 12.

⁷Ibid.

is a component part.

The Standard's failure to provide guidelines or requirements specifying the proper procedure for conducting an adequate and suitable system analysis for the purpose of providing point of operation guards or devices is illustrated in Section 5 of the Standard. Paragraph 5.1, entitled "Responsibility," sets forth the following blanket statement which represents the Standard's instructional content with respect to this most important evaluative function:

"It shall be the responsibility of the employer [system designer/user] to provide and insure the usage of either a point of operation guard or a properly applied and adjusted point of operation device on every operation performed on a mechanical power press."⁸

Such generalized treatment of this most significant aspect of operator protection cannot possibly provide the instruction necessary to insure that an equivalent standard of evaluation will be employed by all system designer/users when providing their systems with adequate point of operation guards or devices.

⁸Ibid., p. 33.

Paragraph 5.2, entitled "Point of Operation Guards," sets forth certain general "design, construction, application and adjustment requirements"⁹ for point of operation guards and then further clarifies these requirements for specific types. These provisions, however, are actually functional requirements to be satisfied by a point of operation guard. Functional requirements are not sufficient to insure proper choice of materials for fabrication, specifications of methods of installation, or procedures for proper adjusting and testing of guards prior to use. Phrases such as in paragraph 5.2(4), "it shall utilize fasteners not readily removable by operator," or in paragraph 5.2.2, "shall be attached securely to," or in paragraph 5.2.3, "shall be interlocked with,"¹⁰ are ambiguous and do not instruct in the specifics of "how" to accomplish the functional requirements of this Section of the Standard. Similarly phrased functional requirements are set forth with respect to point of operation devices in paragraph 5.3. No section of the Standard actually provides design, construction or install-

⁹Ibid., p. 34.

¹⁰Ibid., p. 34; p. 34; p. 36.

ation specifications for the guards or devices covered or procedures for their proper adjustment prior to use.

Concerning responsibilities of system component manufacturers, Section 3 of the Standard does address itself to certain responsibilities of the press manufacturer. However, the provision and intent of this portion of the Standard is again essentially functional in nature. Further, no recognition from either a design specification or functional performance standpoint is made with respect to the press as a general purpose, component machine or to its relationship in the metal forming system. Included as part of Section 3 is the extent of the Standard's coverage of requirements pertinent to the reconstruction or modification of the press component. Paragraph 3.1.2, entitled "Reconstruction and Modification," stipulates:

"It shall be the responsibility of any person reconstructing or modifying a mechanical power press to do so in accordance with Section 3 of this standard."¹¹

The Standard's instructions with reference to reconstruction or modification of the press component provide no guidance

¹¹Ibid., p. 22.

from a design or construction specification standpoint. In addition, there are no requirements governing the types or degrees of alterations that are either permitted or prohibited. This is especially significant since most reconstruction or modification is done without the knowledge or assistance of the press manufacturer. As such, these alterations are performed without a full awareness of all the design and construction considerations which were incorporated into the manufacture of the original machine. As a result, modifications and reconstructions of presses provide the greatest potential for the creation of operational malfunctions which are causally related to a significant number of point of operation injuries. It is imperative that the Standard provide the guidance necessary to insure that such alterations will be performed within regulated limits.

The omissions which have occurred in the codes and standards as a result of the press-system misinterpretation have had significant effects with respect to operator safety in the metal forming system. Several accident studies concerning point of operation injuries are illustrative of the code's and standard's failure to provide adequate guidance in this regard.

Liberty Mutual Insurance Company, in the late 1960's, conducted a study of 389 high cost power press accidents which produced the following:¹²

- A. 135 accidents resulted from no guards or safety devices being provided. Most of these accidents occurred during feeding and removal of the workpiece from the die when the operator accidentally tripped the press.
- B. 50 accidents resulted from not using the guards or safety devices provided. Of these, 26 accidents involved pull-back devices, 17 involved two-hand control devices and 7 accidents resulted from removal of barrier guards.
- C. 96 accidents resulted from guards or safety devices not providing adequate protection while being used. Of these, 46 accidents involved two-hand control devices, 25 involved sweep devices, 20 involved barrier guards or gates and 5 accidents resulted from inadequate pull-back devices.
- D. 59 accidents resulted from guards or safety devices being improperly adjusted, maintained or installed. Of these, 33 accidents were attributed to improper adjustment, 17 to maintenance and 9 accidents to improper installation of the particular guard or device.

¹²Joseph W. Hart, "Power Press Accidents - A Management Problem," Metal Stamping, July 1969, pp. 16 - 19 and "II Causes of Point of Operation Injuries," Federal Register 39, No. 233, 3 December 1974, 41842.

- E. 49 accidents occurred during set up, testing or repair procedures. Of these, 23 accidents occurred during die setting, 10 during testing and 16 accidents occurred while performing remedial repairs.

Of the 389 accidents investigated, 340 of these were related specifically to point of operation protection provided for normal production operation.

In November, 1975, the Office of Standard Development, U. S. Department of Labor, Occupational Safety and Health Administration, issued a report entitled "Investigation and Analysis of Fifty Reports of Injury to Operators of Mechanical Power Presses." This study involved OSHA's investigation of 45 power press accidents (5 accidents were not considered relevant). Tabulation of the conditions involved in these accidents indicated the following: (Note: These accident totals reflect the fact that many of the accidents are included in more than one category.)¹³

- A. 40 accidents involved pull-out safety devices, two-hand control devices, sweep

¹³U. S. Department of Labor, Occupational Safety and Health Administration, Office of Standards Development, Investigation and Analysis of Fifty Reports of Injury to Operators of Mechanical Power Presses, (Washington, D.C.: Government Printing Office, 1975) pp. 1-29.

devices, fixed barrier guards and movable barrier devices that were either improperly installed or adjusted or were bypassed or ignored by the operator.

- B. 5 accidents occurred when no safeguards were provided.
- C. 15 accidents involved inadvertent actuation of the press. This included unintentional tripping of the press by foot trips and two-hand devices which were not properly located.
- D. 4 accidents resulted from failures of press braking systems. (It was determined that of the 45 accidents analyzed, in only one instance could brake monitoring have been used to any advantage.)
- E. 41 accidents involved worker factors such as unsafe acts, lack of operating experience, and second party contributions.
- F. 12 accidents were related to inadequate hand-tools.
- G. 14 accidents involved poor maintenance.
- H. 23 accidents related to poor supervision.
- I. 14 accidents involved the use of incentive pay systems.
- J. 9 accidents were related to the lack of safety rules.

As indicated in the above, conditions of improper installation, adjustment, or use of guards or devices were involved in 40 of the 45 accidents analyzed.

The Office of Standards Development, U. S. Department of Labor, Occupational Safety and Health Administration, issued a semi-annual report dated January 15, 1976, entitled "Analysis of Reports of Point of Operation Injuries on Mechanical Power Presses." This study, which covered the inclusive period of July 1 to December 31, 1975, involved the analysis of 306 power press accident reports. Of this total, 257 of these accidents occurred during normal production operation and 49 occurred during setup and/or maintenance operations. Summarization of the accident causes/contributing factors cited in the 257 normal operation accidents indicated the following: (Note: The accident totals reflect the fact that many of the accidents are included in more than one category.)¹⁴

- A. 123 accidents involved guards or safety devices that were either improperly worn, adjusted or inadequate or were defective, removed or bypassed.
- B. 65 accidents occurred where no safeguards were provided.
- C. 57 accidents involved failure to use hand-tools when cleaning scrap or jammed parts,

¹⁴U. S. Department of Labor, Point of Operation Injuries, pp. 1-11

or feeding material in the die area.

- D. 40 accidents involved press control (electrical or mechanical defects) and included brake failures, broken cams, valve failures, die failures, electrical shorts, etc. Maintenance factors were also included. (This category was a catch-all in nature and did not reflect any specific accident trends.)

Of the 257 accidents which occurred during normal production operation, nearly half of these (123 accidents) were caused by or specifically related to deficiencies in the point of operation safeguards which were provided. This number does not include the 65 accidents where no safeguards were provided.

The results of these studies are clearly indicative of the unsatisfactory caliber of the point of operation protection presently being employed. This is a direct reflection of the manner in which the system designer/user has evaluated the metal forming system to determine its safeguard needs, provided for the design and construction of the guards and devices necessary, secured the installation of these configurations and provided for their adjustment and testing prior to use. The system designer/user's unsatisfactory level of performance in these areas must be considered a reflection of the codes' and standards' failure

to provide instruction and guidance with respect to a metal forming system approach to safeguarding. This omission has its origin in the misinterpretation of the true nature and function of the press in the production unit.

While the lack of system guidance is of major concern, it is important to remember that these accident studies also reflect the level of effectiveness that the codes and standards are achieving as a result of their providing only performance or functional requirements with respect to point of operation safeguards. It is evident that definite design, construction and installation specifications, as well as specific adjustment and testing procedures, are also necessary if present codes and standards are to be applied effectively.

The effects or consequences of inadequacies and omissions in the contents of authoritative codes and standards are not limited in scope to the point of operation injury itself. Most injuries involving power presses are merely entrees into the legal network where such occurrences are eventually molded into product liability litigations in the courts.

As recognized authoritative sources, the codes and standards are looked upon as providing a gauge or measure by which to judge the performance of the system in light of the point of operation injury that is in question. The ability of these sources to provide a suitable standard weighs appreciably in the proper determination of liability for the injury incurred during the metal forming system's use. Unfortunately, the codes and standards are hard-pressed to provide either adequate or accurate information. Since they do not recognize or address themselves to the metal forming system, the codes and standards are concerned only with the press. As a result, the application of the codes and standards, in these instances, gives the lay jury member the impression that the press and the metal forming system are one and the same. In many cases, the inference of equivalency leads to the erroneous conclusion that an injury arising out of the system's function is an injury incurred on the press alone.

Present codes and standards contain no limitation provisions with respect to machine life. The consequences of this omission are amplified by the lack of adequate statutes of limitations in most state's laws. The absence

of any statutes of limitations based on the date of manufacture of machinery involved in industrial accidents has resulted in retrospective application of the codes and standards rather than perspective usage as intended. This is especially significant in systems involving early vintage presses and other components. In effect, these authoritative sources are implying that early vintage presses, as well as other system components, should in design and function appear on a par with equipment of present vintage. With respect to the press component in particular, the codes and standards are inferring that age, number of service hours, and degrees of alteration or modification, are not relevant to the proper functional performance of the machine. In particular, operational malfunctions due solely to consequences of press age and service hours are erroneously being regarded as design defects, rather than practical examples of the fact that nothing can last forever!

The combination of omissions of system related instructions and requirements in the codes and standards and the lack of statutes of limitations, has resulted in a tremendous increase in product liability litigation in the courts. These actions, in turn, have forced judgments or

settlements upon press manufacturers for injuries that, in many cases, were the result of the metal forming systems involved and not their component machines. Frequently, the monetary values of these damages are substantial. As a result, the press manufacturer's liability insurance costs have substantially risen. A study involving eleven press builders who had shipped a total of 338,199 mechanical power presses prior to August 4, 1975, revealed that the total insurance premium of these companies, in 1968, was \$274,351.¹⁵ In 1975, that premium total was \$1,981,440. The following increases were typical: \$3,024. to \$168,659., \$5,747. to \$64,675., and \$2,754. to \$24,000. These increases are usually reflected in an accompanying rise in the manufacturer's product's selling price. This economic action, ultimately affects retail prices and the individual consumer.

The ability of present codes and standards to provide the instructional and regulatory functions necessary to insure adequate operator protection for the metal forming system requires that these authoritative sources recognize

¹⁵Anderson Ashburn, ed., "The Crisis for Manufacturing in Liability Litigation," American Machinist Special Report 688 (June, 1976):69.

and make provisions for a system approach to point of operation safeguarding. The frequency of point of operation accidents is indicative of the deficiencies in present applications of the safeguards available and in the content of the codes and standards upon which their use is predicated. The inclusion of system-oriented specifications is necessary if these authoritative sources are to provide the system designer/user with effective instruction and regulation with respect to system protection. In this regard, recognition and acceptance of the component function of the press as only one element of the metal forming system is a fundamental requirement.

CHAPTER V

CONCLUSIONS

A metal forming system approach is essential to providing adequate point of operation safeguards for the production unit. Individual system component manufacturers do not have the information required to adequately provide such operator protection. The possible variety in content and arrangement of the press and other components in the systems created requires their full definition in order to adequately evaluate and provide the safeguards required for their respective points of operation. This is essential to the safeguard's ability to reflect in its own design and function the characteristics of the particular metal forming system involved.

The present authoritative codes and standards fail to recognize the true form and content of the metal forming system and the component relationship of the press in that production unit. No instructions or requirements reflecting system considerations are set forth in the contents of these authoritative sources. As a result, the approach to the providing of system point of operation safeguards is based on considerations related only to the press component

and not the total system configuration for which the safeguards are intended. In addition, these codes and standards are functional or performance-oriented and provide no instructions or requirements pertinent to design, construction, installation or testing of these safety configurations or any other system component. The application of these codes and standards in their present form and content provides ample illustration of their insufficient level of effectiveness.

The three representative studies of metal forming system point of operation injuries involving mechanical power presses, as reviewed in Chapter IV, clearly indicate that adequate point of operation safeguards are not being provided. These studies show that insufficiencies in operator protection are divided into three general categories:

- A. Safeguards provided, but improperly installed, adjusted or circumvented by the operator.
- B. Safeguards, although properly installed, provided insufficient protection.
- C. Safeguards not provided.

The exclusion in most state's laws of any statutes of

limitations based on the date of manufacture of machinery involved in industrial accidents has further hampered the effectiveness of present codes and standards. While intended to be perspective, the failure of these authoritative sources to include any reference or requirement relative to practical limits of equipment life has resulted in their being applied retrospectively. Malfunctions of the press and other system components due solely to consequences of machine age, have been termed defects in design and, thus, have provided viable grounds for legal action. The legal application of these codes and standards as a measure upon which to evaluate the performance of the metal forming system and its components, has, in part, influenced the substantial increase in product liability litigation. The content of these authoritative sources has permitted inappropriate interpretations which have contributed toward substantial economic consequences for machine manufacturers as a result of the improper determination of liability with respect to point of operation injuries.

Any meaningful approach toward permanent reductions in point of operation injuries must be predicated on the recognition of the metal forming system, in design and

function, as the true production unit. Not until this is accomplished can the required system criteria be developed and included in present codes and standards. Such additions are essential if these authoritative sources are to impart the instruction necessary to insure the provision of proper system safeguards for the protection of the operator.

CHAPTER VI

RECOMMENDATIONS

Present power press codes and standards must be re-evaluated and revised to include the metal forming system as the basic parameter upon which point of operation safeguards are provided for the protection of the operator. The following provisions must be reflected in these revisions:

- a. Recognition of the metal forming system is essential, with a complete definition of the system's design and function, setting forth the individual component categories involved.
- b. Design and functional specifications must be provided for each component category. These provisions must include specific requirements with respect to the responsibilities of the individual component designer/manufacturer for his particular component as well as toward the system where his element will be utilized.
- c. Material specifications and design and construction requirements must be provided which incorporate rea-

sonable limits on "life" expectancies for the individual system components. Operational and safety specifications relating to the component and to the system must also be included.

- d. Design and functional specifications must be provided for the designer/user of the system. These provisions must include specific requirements with respect to acceptable combinations of components to insure a compatible and safe system operation. More importantly, they must specify the designer/user's responsibility for providing the system point of operation safeguards required for proper protection of the operator.
- e. Guidelines and requirements relating to the modification or reconstruction of individual system components are also necessary. Specifications outlining the extent of and the manner in which alterations are to be performed are also essential. Equally important, the extent of the designer/user's responsibilities with respect to such revisions as they affect the individual component and the operation and safety of the system as a

whole, must be clearly delineated.

- f. Design and functional specifications must be provided for the designer/user to insure that proper system considerations are reflected in point of operation safeguards. Requirements must be set forth to guarantee that a uniform standard of system evaluation will be employed in the determination of essential safeguards. In addition, safeguard design, construction and installation specifications, including material requirements, should be provided. These are necessary in order to properly guide the designer/user in "in house" fabrication of safeguards as well as in evaluating the acceptability of safeguards that may be provided by others.
- g. Finally, specific adjustment and testing procedures should be included to insure the proper functioning of the provided point of operation protection prior to its "on line" use.

Statutes of limitations should be added to state laws pertaining to industrial machinery to provide limitations

based on date of manufacture of machinery involved in industrial accidents. Presently, statutes of limitations make provision only with respect to the time period permitted for the injured party to seek recovery. The statutes in this regard start to run at the time the injury occurred. With respect to industrial accidents, limitations on injury recovery have no dependence upon either the date of manufacture and shipment of the machine involved or the machine's physical condition at the time of the accident. A machine may provide proper function for many years and then be involved in an accident which can result in the manufacturer being named in a legal action for providing a defective machine. This can occur whether the machine is still being operated by the original owner or has been resold, or if it has been maintained in its original design or been modified.

Either of the following forms of statutes of limitations must be incorporated into present state laws in order to provide an adequate and equitable solution to this critical problem:

- a. A statute of limitations should be adopted to provide that if a machine furnishes trouble-free service for a given number of years, then it is

to be presumed to have been designed and manufactured without defect. (North Carolina has adopted such a statute and has set a period of five years as an appropriate operating time requirement for the machine.) A statute of this form would rectify the "limitless" liability to which the manufacturer is presently subjected as a result of a malfunction of his machine due solely to old age. However, such a statute would not prevent the manufacturer from being sued on the grounds of a failure to properly warn the operator of danger.

- b. Provision should be made to specify that existing statutes of limitations, in general, apply from the date upon which an act occurred, rather than from the date upon which an injury resulted from that particular act. Thus, with respect to a defective machine, the statute of limitations would run from the date the machine was built (the act) and not from the date of an injury resulting from the defect in that machine. This form is less popular since, in essence, it is setting a limitation on the citing of any defect(s) contained in the ori-

ginal machine. The previous statute form provides a more positive function, since it limits legal action against a machine which has proved itself free from defect(s) by the test of time.

The inclusion of a system approach to safeguarding in the codes and standards will provide the practical, instructional function necessary to reflect the specific characteristics of the metal forming system in the safeguards that will be utilized. Adoption of adequate statutes of limitations will help provide valid guidance toward determining actual liability and will properly direct recovery for point of operation injuries which occur as a result of a failure to conform to the system provisions of the codes and standards.

The implementation of these recommendations in their respective areas of application is necessary to any viable effort toward a permanent reduction in injuries.

APPENDIX

Figure 1 - THE METAL FORMING SYSTEM

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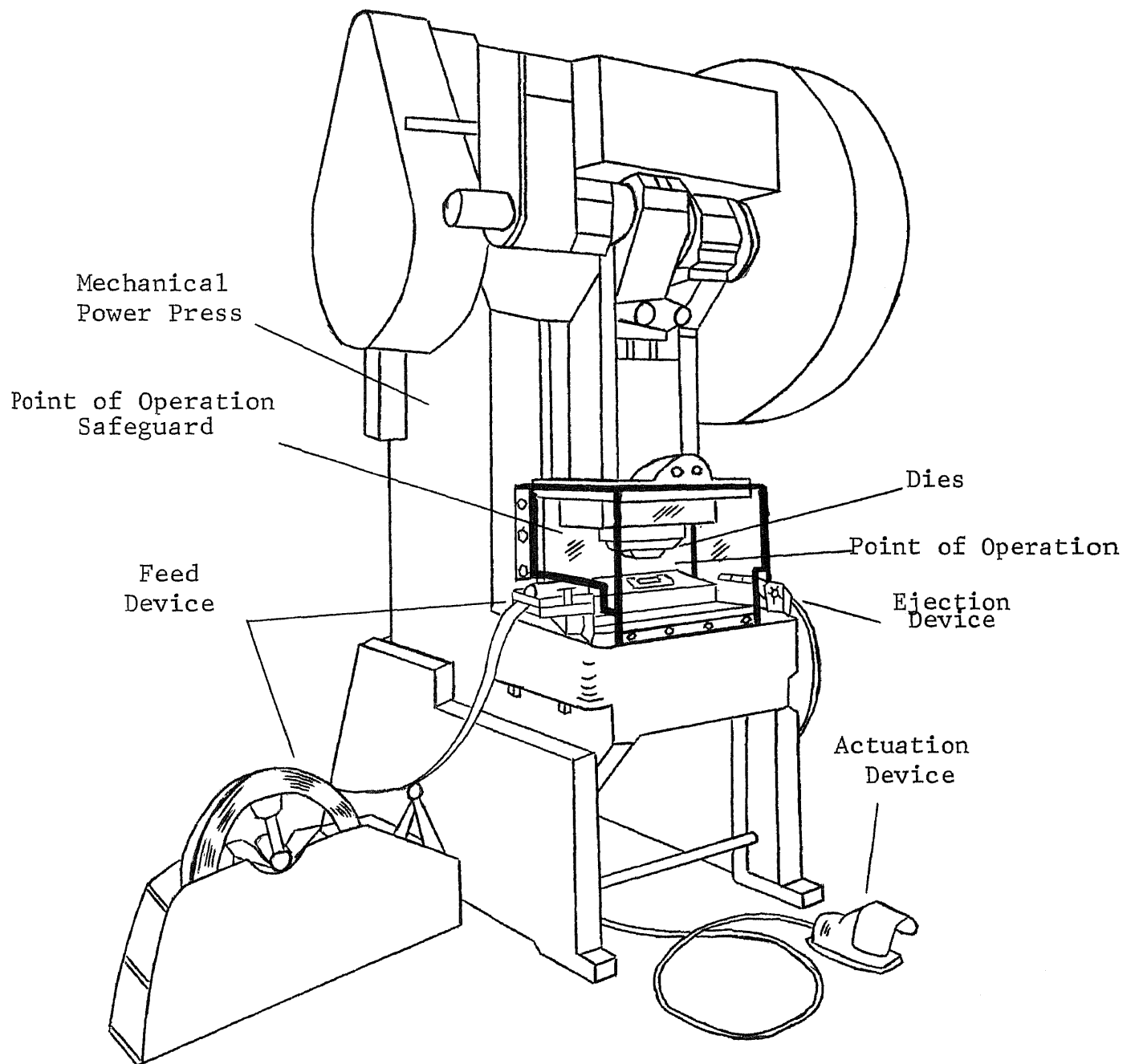


FIGURE 1

THE METAL FORMING SYSTEM

REFERENCES

Accident Prevention, A Workers' Education Manual. Geneva, Switzerland: International Labour Office, 1961, pp. 42-51.

American National Standard Safety Requirements for the Construction, Care and Use of Mechanical Power Presses, ANSI B11.1 - 1971. New York: American National Standards Institute, Inc., 1971, pp. 12, 14, 18, 22, 23, 33-42.

"Analysis of Reports of Point of Operation Injuries on Mechanical Power Presses," Semi-Annual Report, United States Department of Labor, Occupational Safety and Health Administration, Office of Standards Development, January 15, 1976, pp. 1-11.

Ashburn, Anderson (ed), "The Crisis for Manufacturing in Liability Litigation," Special Report 688, June 1976, American Machinist, June, 1976, pp. 66-80.

Baldwin, Doris, M., "The Power Press Controversy - A Status Report," Job Safety and Health, vol. 4, no. 5, May, 1976, pp. 12-16.

Boston, Orlan William, Metal Processing. New York: John Wiley and Sons, Inc., 1941, pp. 500-518, 523-539.

"II Causes of Point of Operation Injuries," Federal Register, vol. 39, no. 233, pp. 41823-41962, Part I. Washington, D. C.: General Services Administration, National Archives and Records Service, Tuesday, December 3, 1974, p. 41842.

Doyle, Lawrence E., Manufacturing Processes and Materials for Engineers, Second Edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969, pp. 300-319.

Federal Register, vol. 39, no. 125, Part II. Washington, D.C.: Department of Labor, Occupational Safety and Health Administration, Occupational Safety and Health Standards, Thursday, June 27, 1974, pp. 23723-23727.

Federal Register, Reprinted from Sections 1910.211(d) and 1910.217 in their entirety, June 27, 1974 and December 3, 1974. Washington, D.C.: Department of Labor, Occupational Safety and Health Administration, Occupational Safety and Health Standards.

Handbook of Accident Prevention for Business and Industry, Second Edition. Chicago, Illinois: National Safety Council, 1958, pp. 30-33, 42-44.

"Handling Finished Pieces at Power Presses," Data Sheet 534, Chicago, Illinois: National Safety Council, 1963.

Hart, Joseph W., "Power Press Accidents - A Management Problem," Metal Stamping, July, 1969, pp. 16-19.

Industrial Safety Handbook, William Handley(ed.). London: McGraw-Hill Publishing Company Limited, 1969, pp. 279-284.

"Inspection and Maintenance of Mechanical Power Presses," Data Sheet 603, Chicago, Illinois: National Safety Council, 1967.

"Investigation and Analysis of Fifty Reports of Injury to Operators of Mechanical Power Presses," Final Report, United States Department of Labor, Occupational Safety and Health Administration, Office of Standards Development, November, 1975, pp. 1-29.

Power Press Safety Manual, Second Edition. Chicago, Illinois: National Safety Council, 1972, pp. 16-25, 29-42, 52-54.

The Principles and Techniques of Mechanical Guarding, OSHA 2057. Washington, D.C.: United States Department of Labor, Occupational Safety and Health Administration, August, 1973, pp. 7-12.